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HOW DO UNIVERSITY STUDENTS SELECT AND USE THEIR LEARNING TOOLS? A MIXED-METHOD STUDY ON PERSONALISED LEARNING (21)

Patrick Gross
University of Hohenheim, gross.p@uni-hohenheim.de

Andreas Schmid
University of Hohenheim, andreas.schmid@wi1.uni-hohenheim.de

Johannes Gettinger
University of Hohenheim, johannes.gettinger@wi1.uni-hohenheim.de

Philipp Melzer
University of Hohenheim, melzer@uni-hohenheim.de

How Do University Students Select and Use their Learning Tools? A Mixed-Method Study on Personalised Learning

Patrick Gross, Andreas Schmid,
Johannes Gettinger, Philipp Melzer, Mareike Schoop
Information Systems Group,
University of Hohenheim,
70593 Stuttgart, Germany
gross.p@uni-hohenheim.de
andreas.schmid@wi1.uni-hohenheim.de
johannes.gettinger@wi1.uni-hohenheim.de
philipp.melzer@wi1.uni-hohenheim.de
schoop@uni-hohenheim.de

Abstract

Universities often blend traditional learning and e-learning by providing software licenses, electronic learning materials, and access to Learning Management Systems. Following the idea of personalised learning in higher education, students are free to choose between a wide range of learning tools constructing their Personalised Learning Environment. However, the characteristics of the chosen tools need to match the characteristics of the learning tasks to support students adequately. In the present paper, a mixed-method approach is used to analyse which types of tools are used in practice and which types of learning tasks are performed using these learning tools. Furthermore, important factors influencing the decision to select learning tools are identified. This study shows that a wide array of learning tools is used in practice. Although students consider individual factors (such as perceived ease of use and task-technology fit) to be most important when selecting their tools, several exogenous factors such as the lecturers' targeted pedagogy, social norm and the occurrence of higher order thinking skills limit the range of adequate learning tools.

Keywords: e-learning, higher education, self-regulated learning, personalised learning environment, mixed-method approach

1.0 Introduction

An important political objective in many countries is providing a personalised form of higher education (Johnson et al. 2016). Personalisation encompasses individualisation (i.e. adapting to the pace of individual learners) as well as differentiation (i.e. adapting the method of instruction to the learners' preferences) (Attwell 2007, U.S. Department of Education 2010). Personalised education can trigger higher motivation and better learning outcomes of learners due to its ability of considering the heterogeneity of students, e.g. in their characteristics, abilities, educational and cultural backgrounds. However, supporting or enabling such personalisation requires the lecturers to put in much effort for carefully analysing their students. This is possible in co-presence learning scenarios involving a small number of students but gets more difficult as the number of students increases.

Electronically supported methods to enhance personalisation and especially differentiation use either automated approaches based on Learning and Predictive Analytics (Chatti et al. 2012) or make the students themselves responsible for the personalisation following the constructivist learning paradigm (Melzer and Schoop 2015). Our research focuses on the latter approach putting the learners in charge of constructing new knowledge being assisted by lecturers. Traditional knowledge transmission from a lecturer to the learners becomes less important. Prior research has focused on learning or cognitive styles to personalise learning (Coffield et al. 2004; Bostrom et al. 1990). However, findings regarding a match between specific learning styles and learning methods provide no clear pattern (Gupta and Anson 2014; Pashler et al. 2009). Consequently, we follow a new stream of research investigating the relationship between learning tasks and learning tools (Melzer and Schoop 2015). The self-regulated selection and usage of such tasks and tools enables students to personalise their learning in so-called Personalised Learning Environments (PLEs). Whilst such tasks provide an objective level of analysis, they have also been shown to be an important predictor for the adoption of learning tools (Sun and Wang 2014; McGill and Klobas 2009).

Following this stream of research, this study aims to analyse the selection and use of learning tools based on learning tasks in higher education. In our research, we focus on the identification of relevant factors influencing the selection of learning tools in a self-regulated learning environment. In the following, we split our research into three research questions: (RQ 1) which learning tools are used by learners in practice, (RQ 2) why are these learning tools selected, (RQ 3) for which learning tasks are these tools used? By answering these research questions, we aim to create an extended understanding of the relevant factors influencing tool selection as well as the complex relationship between learning tasks and learning tools. Such an understanding can be used to facilitate the process of differentiation providing guidelines which types of tasks and tools match specific learning methods.

To answer our research questions, we conducted a mixed-methods study (Venkatesh et al. 2013) analysing university students' learning in practice. We asked students in a survey which learning tools they used specifying their most important influence factors regarding tool selection in general (RQ 1 & RQ 2). Performing observations, we complemented these results with a notion of how these tools are used (i.e. for which learning tasks and in which context; RQ 1 & RQ 3). Finally, we interviewed students to expand the findings and explain the underlying reasons of tool usage (RQ 2 & RQ 3). Section 2 provides foundations regarding previous studies analysing learning tasks and tools as well as learning tool adoption, while section 3 explains our methodology leading to a presentation of the results in section 4. Finally the results are integrated and discussed in section 5 summarising their main implications in section 6.

2.0 Theoretical Background

The theoretical background of this study is twofold: (1) Starting from an educational point of view, we provide an overview of personalised learning in electronic scenarios. Therefore, we define and classify available tools according to their predominant tasks. (2) We present a theoretical framework of influence factors relevant for the selection and usage of those tools stemming on the IS literature.

2.1 Personal Learning Environments in Higher Education

Personal Learning Environments are not monolithic software applications but rather personalised sets of software tools used for learning focusing on web 2.0 tools but also including other kinds of software such as e-mail software or even operating systems (Attwell 2007). The selection and use of tools in a PLE allows learners to personalise learning. Encompassing numerous tools, PLEs require a wide definition of e-learning, describing all forms of IT-supported learning as e-learning (Attwell 2007). The idea of PLEs is rooted in informal and lifelong learning, claiming that employees are responsible for sustaining their employability and, therefore, have to organise their learning process constantly for staying up-to-date. In contrast to PLEs, Learning Management Systems (LMSs) are institutionally-provided software systems providing coherent functionality w.r.t. user management, course management, communication facilities, and learning tools to access and change course contents (Schulmeister 2003). Analysing higher education at universities, we find a broad mixture of learning environments, blending co-presence lectures with institutionally-based LMSs and learner-based PLEs. Students, for example, would rather refer to social networking services for collaboration tasks although their university provides access to a LMS with similar features (Lampe et al. 2011). As a part of higher education, university students have the freedom to decide what to learn and how to learn. This also holds true for following their individual style of learning defining their learning tasks and preferred learning tools. Reflecting such behaviour, this study investigates electronic learning activities in PLEs.

2.2 A Classification of Learning Tasks and Learning Tools

Based on the definition of a PLE, we classify e-learning activities combining learning tasks and learning tools. Whilst a task cannot be performed without a tool, learning tools usually support several tasks. Thus, a meaningful classification of learning activities must combine tasks and tools to achieve specific learning objectives (e.g. reading a wiki article vs. writing a wiki article). We follow a holistic approach where learning tools can be used with all kinds of devices. Co-presence courses still play a dominant role in higher education often being extended to blended learning scenarios combining presence and distant learning (Garrison & Vaughan, 2011). Thus, the learning materials, which are provided by the lecturer, as well as the location of learning are relevant objects of analysis. We distinguish between self-regulated learning and institutionalised learning (i.e. lectures, example classes, tutorials etc.). In higher education, learning materials such as scripts, slides, or exercises can be accessed also outside the lecture if provided in printed or electronic form. Learning tools can be further classified along the dimensions of negotiation and production of an artefact (Bower et al. 2010). First, tools can be used by an individual or at the same time by a group of collaborating learners negotiating over the learning content. Second, tools facilitate implicit knowledge transfer while other tools require the construction of an artefact representing the result of the learning process. Figure 1 presents the four classes of e-learning pedagogy along with several groups of tools.

A transmissive pedagogy (T) focuses on the documentation of provided learning materials. This pedagogy requires neither negotiation between learners nor production of artefacts. Tools supporting this kind of pedagogy are screen recording tools (e.g.: Camstudio, Wink). A dialogue-oriented (D) pedagogy facilitates the communication

between learners without generating an artefact apart from the discussion itself. Therefore, blogging (e.g.: Blogger, Wordpress), micro-blogging (e.g.: Twitter, Plurk), podcasts & audio consumption and creation (e.g.: Audacity, Voxopop), social bookmarking (e.g.: Delicious, Diigo) and communication tools (e.g.: Facebook, Whatsapp) are exemplary tools supporting a dialogue-oriented pedagogy. A constructively-oriented pedagogy (C) requires the creation of an artefact. Here learners do not engage in negotiations but create an artefact as the result of the learning process. Tools supporting a constructive approach are mind mapping (e.g.: Freemind, Xmind), video consumption and creation (e.g.: Youtube, Adobe Premiere), image creation (e.g.: Pixlr, Adobe Photoshop Express), presentation (e.g.: Apple Keynote, Prezi), and writing and annotation tools (e.g.: Microsoft OneNote, PDF Xchange Viewer). Finally, a co-constructive (CC) pedagogy focuses on the collaborative creation of artefacts and therefore requires a combination of negotiation and production. Tools supporting this pedagogy include wikiing (e.g.: Wikipedia, PBwiki) and shared document creation tools (e.g.: Dropbox, Microsoft OneDrive). For example, learners creating a wiki article use several iterations to work jointly on the article with each learner adding and modifying (parts of) the article. Learning Management Systems, however, provide a large array of functionalities making it possible to address all kinds of pedagogies. Thus, they are displayed in parallel to our taxonomy of pedagogies.

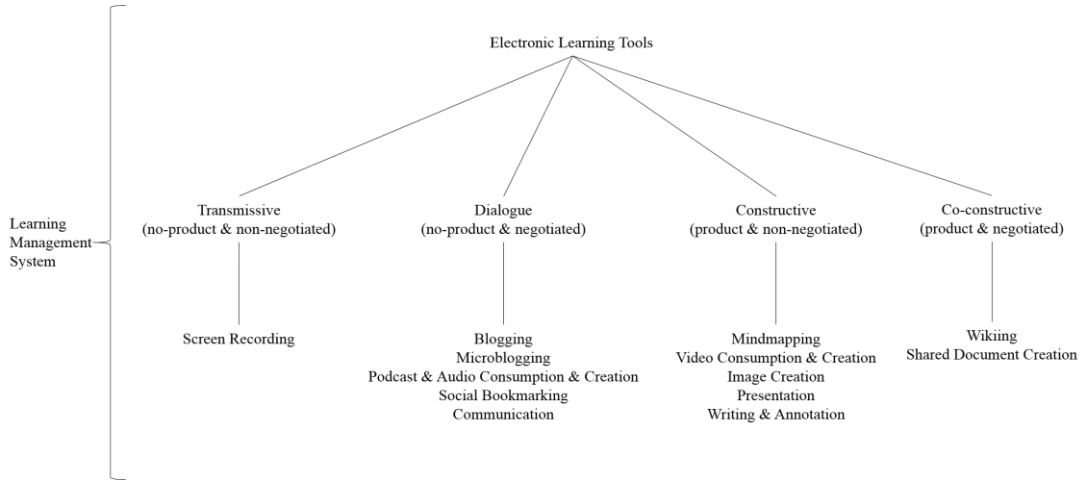

Figure 1. Taxonomy of pedagogies with corresponding groups of learning tools (adapted from Bower et al., 2010, p.183)

E-learning inherently involves decisions on learning tasks to achieve specified learning goals. Following Bloom's revised taxonomy (Anderson and Krathwohl 2001), learning objectives can be classified specifying the cognitive process dimension as well as the knowledge dimension (cf. table 1). The cognitive process dimension describes cognitive processes ordered according to their complexity from lower order thinking skills (i.e. remember, understand, apply) to higher order thinking skills (i.e. analyse, evaluate and create), with each step requiring all previous ones. Anderson & Krathwohl (2001) assign several learning tasks for each cognitive process, e.g. understanding can be implemented by the learning tasks of interpreting,

exemplifying, classifying, summarising, inferring, comparing, or explaining. The knowledge dimension refers to the subject matter content and can be distinguished into four categories: (1) Factual knowledge as the basic elements that learners will have to know; (2) Conceptual knowledge describing the interrelationship between the basic elements within a larger structure, including e.g. classifications, categories, principles, generalizations, theories, and models; (3) Procedural knowledge showing how to do something, including e.g. algorithms, techniques, methods; (4) Metacognitive knowledge describing knowledge and awareness of cognition in general. Combining learning tasks in the cognitive process dimension and the knowledge dimension, Bloom's revised taxonomy can be used to structure learning processes ex ante from a teacher's perspective as well as ex post from a researcher's perspective.

Looking at PLEs, each learning tool is appropriate for specific combinations of cognitive processes and knowledge levels and thus fits specific learning tasks. Table 1 provides the framework for web 2.0 learning design (Bower et al. 2010) showing a possible classification of the groups of learning tools (cells) analysed in this study to the respective knowledge dimension (rows) and cognitive processes respectively underlying learning tasks (columns). However, we reduced the numerous permutations of learning objectives and pedagogies to the most characteristic ones, presenting the matching pedagogy in brackets.

		Cognitive Process Dimension					
		Remember	**Understand**	**Apply**	**Analyse**	**Evaluate**	**Create**
Knowledge Dimension	**Factual Knowledge**	Microblogging (D)	Social Bookmarking (D)	Image Creation (C)	Writing & Annotation (C)	Wikiing (CC)	Image Creation (C)
	Conceptual Knowledge	Image Creation (C)	Presentation (C)	Video Consumption & Creation (C)	Podcast & Audio Consumption & Creation (D)	Blogging (D)	Shared Document Creation (CC)
	Procedural Knowledge	Podcast & Audio Consumption & Creation (D)	Podcast & Audio Consumption & Creation (D)	Screen Recording (T)	Presentation (C)	Writing & Annotation (C)	Image Creation (C)
	Metacognitive Knowledge	Mindmapping (C)	Mindmapping (C)	Blogging (C)	Blogging (C)	Communication (D)	Mindmapping (C)

Table 1. Framework of Web 2.0 Learning Design (adapted from Bower et al. 2010, p.190-191)

2.3 Individual Factors: Task-Technology-Fit and Technology Acceptance Model

The theory of Task-Technology Fit (TTF) can explain the relationship between the previously discussed concepts of learning tasks and learning tools (Goodhue and Thompson 1995). TTF highlights the importance of aligning the characteristics of tasks and tools used to support the task. Accordingly, learners should pick those learning tools that fit the characteristics of the learning task (Sun and Wang 2014). For example, the medium "video" might be an appropriate tool to remember the procedure of an algorithm. Furthermore, a fit between learning tasks and learning tools positively influences the perceived impact on learning and the utilization of a Learning Management System, however without a direct effect on students' grades (McGill and Klobas 2009). TTF has also been analysed from a students' as well as

lecturers' perspective showing that lecturers perceive a lower fit between task and technology than the students because they have to fulfil more complex tasks within the LMS (McGill and Hobbs 2008).

In contrast, the Technology Acceptance Model (TAM) explains the adoption und use of a software (Davis et al. 1989). TAM contends that the perceived usefulness and perceived ease of use of a software and its tools act as predictors for the users' intention to actually make use of it. TAM has been supported in many empirical studies and has recently been extended to the context of learning software (Sung Youl Park 2009; Lee 2006; Lee et al. 2005). According to TAM, learners being able to choose between two systems adequately (in terms of the TTF) supporting the learning task, are more likely to choose the tool characterised by a higher ease of use and usefulness. Specific tool functionalities such as communication facilities, and consistent multimedia contents have been identified as critical determinants to enhance ease of use and usefulness which might be transferable to specific web 2.0 tools. However, analysing course websites or LMSs no influence has been found regarding individual characteristics of the users (Selim 2003; Pituch and Lee 2006).

Dishaw and Strong (1999) created and evaluated an integrated TAM and TTF model defining task-technology fit as a predictor of perceived ease of use and perceived usefulness which consequently influence actual tool usage. In this study we use this combined model as a basis for our theoretical considerations having task- and tool-related factors at the centre (cf. figure 2). Both TAM and TTF focus on subjective constructs showing the individual perception of users. Thus, we will refer to them as individual factors in the remainder of the paper.

2.4 Exogenous Factors

To answer our research questions on how and why specific learning tools are used, we complement these individual factors with exogenous factors preceding tool selection. Collaborative learning is a key concept of Constructivism as well as of web 2.0 (Garrison 2011). Therefore, social norm in learning groups among peers as well as between learners and lecturers is an important factor making tool selection dependent on (1) the lecturers' advice, (2) peer preference leading to network effects (Gröhn 1997), and (3) the total number of users of such collaboration tools inducing effects of critical mass (van Slyke et al. 2007). Learners evaluate their needs against these factors before selecting a specific tool. Social norm has been included into the TAM (Venkatesh and Davis 2000) and has also been applied to e-learning showing the importance of the lecturers recommending or integrating specific tools into their teaching styles (McGill and Klobas 2009). Critical mass also has been shown to influence perceived usefulness of LMSs increasing the adoption of such systems as well as the adoption of web 2.0 tools in general (Lee 2006; Lou et al. 2000).

PLE tools are characterised to be open interoperable software under learner control (Siemens 2007). Openness refers to using the tools free of charge as well as learning contents being publicly accessible. However, personal data should remain private. Thus, we include price and data security into our model. Interoperability is a key concept of PLEs enabling seamless collaboration between learners using different tools adhering to common standards. Even open source LMSs still fail to implement such standards. Proprietary web 2.0 tools often deliberately try to avoid interoperability to increase their user base creating lock-in effects (Sclater 2008).

Thus, interoperability between tools and portability describing if a specific tool is usable on different platforms are important factors influencing tool selection.

Figure 2 depicts our theoretical considerations integrating exogenous and individual factors into the TAM and TTF model (Dishaw & Strong 1999). Starting with exogenous factors which are evaluated during tool selection and thus influence task-technology fit, we evolve to the combined model of TAM and TTF explaining actual tool use. While solid lines represent direct relationships confirmed by Dishaw & Strong (1999), dotted lines show indirect relationships.

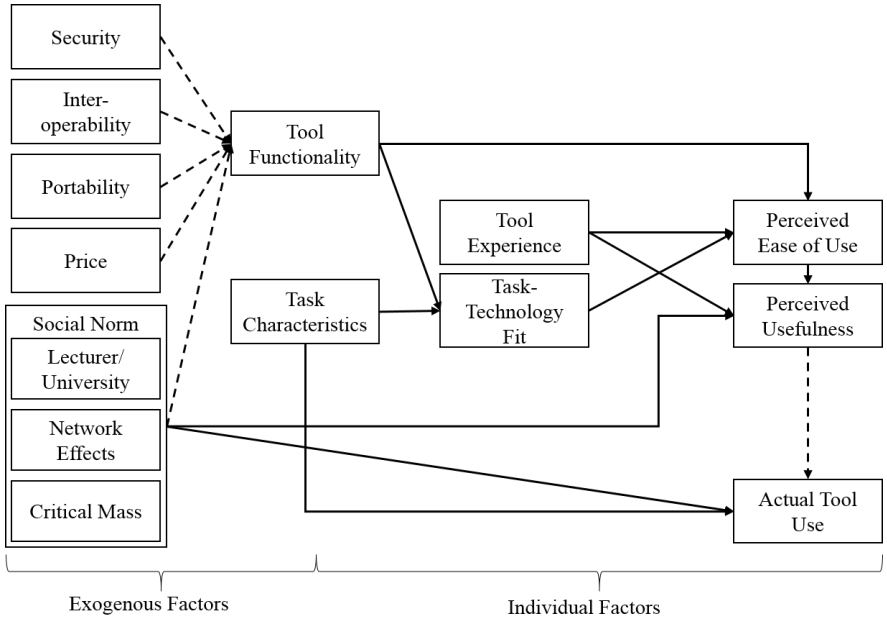

Figure 2. Exogenous and individual factors influencing selection and usage of learning tasks and tools (adapted from Dishaw and Strong 1999, p. 13)

3.0 Methodology

We used a mixed-method approach to answer our research questions. We investigated which tools are used by learners (RQ 1), the reasons of usage (RQ 2), and for which tasks and in which contexts these tools are used (RQ 3). Our research is based on a strong theoretical foundation (cf. figure 2) and provides a new study context. Therefore, we followed the recommendation to start with a quantitative survey first, sequentially followed by a qualitative study with observations and interviews which may offer additional insights (Venkatesh et al. 2013). For each of the three research questions, several methods were used to get a complete picture of learning tool use at universities. The survey addressed the tools used by the learners and their selection criteria in general (RQ 1 & 2). Observations also allowed insights into the tools used (RQ 1) but focussed on the tasks and the context of their adoption (RQ 3). Finally, interviews were conducted to expand our results regarding the reasons for choices, tasks and contexts of tool adoption (RQ 2 & 3). Applying several research methods for our research questions offers the opportunity to draw meta-interferences.

3.1 Quantitative Survey

Since our extended understanding of e-learning covers more than just a specific type of tools, the main goal of this part is to identify which types of tools are used for e-learning (RQ 1) and which factors are important when selecting a tool (RQ 2) from the student's point of view.

Besides demographic data concerning age and gender of the participants, information about their course of study and their respective year were collected. The participants were then asked to estimate their time using devices on an average working day, revealing their device familiarity (Igbaria et al. 1995). As our understanding of learning tools is not bound to certain devices, the term devices refers e.g. to computers, tablets, and smartphones.

To find out which types of tools are used, we followed the categorisation based on the web 2.0 framework (Bower et al. 2010) and Bloom's digital taxonomy (Churches 2009). Participants were asked which of these tools they use and whether they refer to additional tools not explicitly listed. Afterwards, the participants provided information for each tool category as to whether they create own content with these tools. This allows to draw conclusions about the tasks fulfilled, e.g. creating a wiki article or just reading a wiki article. Additionally, the participants were asked about their frequency of learning tool usage during lectures and exercises. This and all following items have been measured on a five point Likert scale.

Furthermore, we included two questions about the tool selection: First, the participants revealed whether the tool selection is based on their own preferences or externally determined. Second, subjects rated the importance of the individual and exogenous factors influencing selection and use presented above. While 67 students started the questionnaire, 41 out of 42 participants completed the questionnaire in a meaningful way. Our sample includes 27 male and 14 female students with an average age of 23.68 years. 18 of the 41 participants are enrolled in Information Systems. Other study programs include Computer Science, Economics, Business Administration, Business Engineering, and Sociology.

3.2 Observations

We engaged in observations to answer the question which and how learning tools are used when faced with certain learning tasks (RQ 2 & 3). These observations were conducted at two universities three to four weeks before the exam period within a timespan of two weeks. Teaching is mostly performed in blended learning scenarios at both universities combining co-presence and distant learning. We addressed that by observing learners in lectures as well as other learning places. Being students ourselves, we were able to choose the complete participant role in our own lectures, while following a participant-as-observer role in other lectures and learning places (Gold 1958). During the observation, we were limited to taking notes. We were not able to collect further information about the observed students and had to make sure to maintain a certain spatial distance.

For the observed lectures, the sampling included lectures differing in the number of student participants (from about 30 students to more than 100 students), study programmes, and media used by the lecturer. Our selection was based on publicly

available information about the lecture, such as intended audience, size, and equipment of the lecture room. During the lectures, we focused on the material provided by the lecturer, media used (e.g. slide show, document camera, blackboard), and whether and which learning tools were used by the students.

Regarding the learning places, our sampling included different learning sites open to all students available for group work (e.g. cafeterias and computer labs) as well as quiet zones (e.g. libraries). We were again only able to take notes about our observations. Our collected data included information about the material used for learning (e.g. lecture notes), learning tools used (in case they were identifiable), and a general description of the learning activity which we later used to categorise the students.

3.3 Semi-Structured Interviews

Finally, we conducted semi-structured interviews to elaborate on our previous insights based on the survey and observation. Besides providing explanations for tool selection (RQ 2), we also gathered information about the students' usage of the particular tools (RQ 3). The interviews allowed in-depth insights for each used tool: The participants had to reveal the specific tasks, the contexts in which the tool was used and why they selected the tool. The sample for the interviews consisted of five male and female students from two universities with different courses of study (automotive engineering, electrical engineering, information engineering, information systems and management).

4.0 Results

In the following, we present our results based on the mixed-method approach.

4.1 Questionnaire Results

From a total set of 41 participants, most participants spend two to three hours per average working day with devices such as computers, tablets, and smartphones ($M = 5.22$, $SD = 1.16$).

From our set of tools and respective pedagogies in the taxonomy, two groups of tools regarding their frequency of use emerge. Almost every one of the 41 students uses presentation tools (100%, C), communication tools (98%, D), video consumption and creation tools (95%, C), shared document creation tools (90%, CC), writing and annotation tools (90%, C), LMSs (88%, ALL), and Wikis (88%, CC). However, only a small number of students refers to tools used for image creation (34%, C), mind mapping (22%, C), blogging (20%, C), podcasting and audio consumption & creation (17%, D), screen recording (10%, T), social bookmarking (5%, D), and micro-blogging (5%, D).

Another goal of the questionnaire was to get an idea of the context and usage of these tools, i.e. creating vs. consuming content. Among the students that indicated the use of specific tools, the majority uses presentation tools (70%, $n = 41$), writing and annotation tools (68%, $n = 37$), shared document creation (63%, $n = 37$), and communication tools (63% $n = 40$) to create content. In contrast, only a minority

create content using LMSs (33%, n = 36), wikis (17%, n = 36), or video tools (15%, n = 39).
Regarding the use of learning tools within or outside university courses, there is a slight tendency of these tools being used outside the courses (M = 3.26, SD = 1.03). Regarding the use of tools for lectures and exercises, 14 participants always or often, 15 participants sometimes, and 12 participants rarely or never use learning tools in lectures and exercises only (M = 3.05, SD = 1.12).
Concerning the tool selection, the decision to select a learning tool is rather self-driven (M = 2.61, SD = 0.97). Whilst 23 participants decide on their own, nine participants state being forced with nine being neutral.

Demographics	Scale	Mean (SD)
Device Usage (n=41)	Almost never (1) - More than 3 hours (6)	5.22 (1.16)
Location of Tool Usage (n=38)	Only inside lecturer (1) – only outside lectures (5)	3.26 (1.03)
Tool Usage in Lectures & Exercises (n=41)	Always (1) – Not at all (5)	3.05 (1.12)
Tool Decision (n=41)	Decide on my own (1) – Forced to choose (5)	2.61 (0.97)

Table 2. Overall Characteristics of Learners

The tool selection was also examined in more detail regarding the importance of different selection criteria for these learning tools. We analysed individual as well as exogenous factors representing our theoretical considerations (cf. table 3). Our results show that on average the individual factors (M = 4.08, SD = 0.61) are perceived as more important than the exogenous factors (M = 3.43, SD = 0.62) for the tool selection ($t(40) = 5.459$, $p < .001$).

Criteria	Factor	Mean (SD)
Ease of Use	Individual	4.49 (0.71)
Task-Technology Fit	Individual	4.22 (0.94)
Price	Exogenous	4.20 (1.08)
Tool Experience	Individual	3.95 (1.05)
Network Effects	Exogenous	3.82 (1.12)
Usefulness	Individual	3.65 (0.94)
Interoperability	Exogenous	3.44 (1.07)
Security	Exogenous	3.24 (1.24)
Used by University/Lecturer	Exogenous	3.17 (1.07)
Portability	Exogenous	3.10 (1.22)
Critical Mass	Exogenous	3.00 (1.14)

Table 3. Importance of influence factors for learning tool selection (n=41)

4.2 Observation Results

In our observations, we could reveal three types of learners (cf. table 4): (1) exam learners preparing for an upcoming exam, (2) students working on their thesis or seminar papers, and (3) exercise solvers, engaging in tasks for their courses.

Regarding tool usage, exam learners use writing and annotation tools to read lecture slides, exercise sheets, and mock exams or additional information resources provided by other universities. They also use wikiing tools to search for additional information. Summaries are created either electronically or by writing on a sheet of paper or record cards. Similarly, students preparing their thesis or seminar papers use writing and annotation tools to create documents. They refer to writing and annotation tools and wikiing tools to search for and read additional information. However, in contrast to the exam learners, the electronic information resources are mostly e-books and scientific papers. The third group focusing on exercises also use writing and annotation tools to work on lecture slides or exercise sheets. Furthermore, some exercises were solved with course-specific software such as Integrated Development Environments (IDEs) or Computer Aided Design (CAD) software. However, for the majority of tasks they work on paper. Additionally, both exam learners and exercise solvers use shared document creation tools and ILIAS – the LMS provided by both universities – to access the lecture material.

Referring to Blooms Taxonomy, the majority of the observed exam learners fulfilled remembering and understanding tasks classified as lower order thinking skills of the cognitive process dimension. In contrast, students working on their thesis or seminar papers fulfil higher order thinking skills such as evaluating and creating. Students solving exercises are engaging in tasks of understanding, applying, and analysing, and are, therefore, cognitively located between the former two groups.

Type of Learner	Fulfilled Tasks	Used Learning Tools
Exam learner	Remembering, Understanding	Wikiing tools, writing and annotation tools, shared document creation tools, LMS
Thesis/seminar writer	Evaluating, Creating	Wikiing tools, writing and annotation tools
Exercise solver	Understanding, Applying, Analysing	Writing and annotation tools, course specific software (e.g. IDEs and CAD), shared document creation tools, LMS

Table 4. Learner types and observed tool usage

An important exogenous factor is social norm. Both universities investigated provide the LMS ILIAS as the single platform to access course materials for facilitating learning. Our observations of students during lectures also revealed the lecturer's strong influence. Depending on the lecturer's presentation style or type of material, students use different tools and engage in various tasks (cf. table 5). Only very few students use electronic devices and learning tools in lectures providing a script in printed or electronic format. Furthermore, lectures in which students have to copy the notes from the blackboard discouraged students to make notes in writing and annotation tools. The presentation materials used in lectures also influence the usage of learning tools. Lecturers who focus on the information presented on slides without

giving further information or examples, providing that script electronically decrease the amount of students using writing and annotation tools for reading and highlighting. Whereas lecturers providing additional information and examples cause students to frequently use electronic devices and learning tools such as writing and annotation tools for reading, highlighting and annotation purposes.

Lecturer	Learning Materials	Use of Devices	Tools	Task
Presenting script	Script available printed & electronically	Nearly none	Writing & annotation tools	Reading
Writing on slides	Script available printed with gaps	None	-	-
Writing script on board/tablet	No script available	Nearly none	Writing & annotation tools	Writing
Presenting slides	Script available electronically	A few	Writing & annotation tools	Reading, highlighting
Presenting slides & giving explanations and examples	Script available electronically	Many	Writing & annotation tools	Reading, highlighting, annotating

Table 5. Influence on tool usage by lecturer

4.3 Interview Results

The results of our interviews overall confirm the results of the quantitative survey regarding influence factors on selection of learning tools (cf. table 3). Especially the importance of social norm is highlighted by the interviewees stating the use of collaboration tools for group work even against their personal preference. If the majority of a learning group already uses specific tools, interviewees stated to be overruled showing the relevance of network effects. Furthermore, participants state that for some tools such as Microsoft OneDrive or Dropbox the decision to adopt them is based on the critical mass of the tools' user base. Furthermore, several interviewees affirm that they use wikiing tools and video platforms only for searching for information rather than for creating new information. Participants state clearly that they are not willing to invest substantial amounts of money in the tools to be used. Thus, these tools would have to be available for free or for little money.

Questioned on the tools they use for image and mind map creation, several interviewees replied that they do not use an electronic learning tool but instead use pen and paper, as these are easier to use. Furthermore, students often lack relevant experience with the respective learning tools. These tools seem to be quite complex for the students, requiring high effort to learn to use them. Images or mind maps for

example are easy to draw on paper while creating them electronically can be cumbersome.

5.0 Discussion

The main goal of our research was to study the use of learning tools in a higher education setting. We used a mixed-method approach to investigate (RQ 1) which tools are used by university students, (RQ 2) the reasons for their choices, and (RQ 3) whether specific learning tasks favour the use of specific tools.

First of all, our results show that by now learning tools have not fully permeated all cognitive process dimensions. Students still prefer pen and paper over learning tools based on the concept of PLEs for higher order cognitive skills such as creating images or mind maps. The reasons for the students' choice might be rooted in the TTF. Higher order cognitive skills typically require the use of more complex tools. As a consequence, students would have to invest time and effort to learn the appropriate use of the respective tool, while they are already familiar with the paper-based alternative.

Regarding research question 1 and the use of learning tools, our results show that students focus in their regular use on specific tools. Besides tools used for communication purposes, the majority of students refer to tools mostly rooted in the constructive and co-constructive type of pedagogy (see Figure 1). In contrast, tools primarily supporting transmissive and dialogue-oriented pedagogy are used by a much smaller number of students. In line with our considerations regarding higher cognitive skills discussed above, the two tools rarely used for supporting co-constructive learning tasks are tools used for image-creation and mind mapping. Therefore, these two tasks do not fully exploit the potential of learning tools. However, we see a different pattern for the use of learning tools in lectures and exercises. Only about one third of the student participants indicate that they use learning tools often or always in lectures and exercises. In contrast, almost one third of our participants indicated that they rarely or never refer to learning tools in lectures and exercises.

The results for research question 2 provides reasons for the observed difference in tool choice and usage. The majority of students indicates that they are free to choose any learning tool and only one fifth of them feels forced to use specific tools. In line with that, students perceive individual criteria rooted in aspects covered by TAM and TTF to be more important than exogenous criteria such as interoperability or network effects. However, these results of the questionnaires are in conflict with the results based on the interviews and the observations. In the interviews, students highlighted the importance of social norm (and thus of exogenous factors) for group activities. Indeed, working in groups requires a group decision for a tool. In a group of learners, the tool selection is strongly based on network effects, so that a tool is selected that is already used by the majority of group members. Consequently, the non-using minority of such tools has a strong incentive to adopt the respective tool. Similarly, tools which would fit a specific task having a high perceived ease of use will not always be chosen, if the perceived critical mass is not reached. Some students e.g. prefer to work with Apple Keynote; however, they use Microsoft PowerPoint instead. Tools such as Microsoft Office or Dropbox are considered to be 'de-facto standards' due to their high degree of market penetration. Tools that have reached the critical mass enable an

easier exchange of files and, therefore, a better support of its users. Our results are in line with prior research showing that in voluntary settings the critical mass has a positive impact on the perceived usefulness of a tool (Lee 2006) and on the intention to use groupware (Lou et al. 2000; van Slyke et al. 2007). Therefore, the choice for specific collaboration tools depends on the number of their users, and critical mass and network effects overrule individual preferences in the selection process of collaboration tools.

We further investigated the impact of how the education institute and its employees design blended learning on the choice of learning tools. Both universities in our study provide a central institutionalised LMS as the single platform to access course materials. Even though students stated in the interviews that they are reluctant to use the LMS, they have no choice but accessing and using the central LMS. Whilst prior research has shown lecturers to perceive different sources of barriers to implement learning (Pajo and Wallace 2007), students are more likely to adopt learning tools when they perceive their use to be important for instructors (McGill and Klobas 2009). Similarly, our results show that a successful integration of technology depends on the instructors' acceptance and usage rather than on the (majority of) student users. The potential of the LMS in such a case is not completely utilized, as it is rather used like a document management system.
Similarly, lecturers as the employees of education institutes exert also an influence on the tool usage via their organisation of courses. In case course material is provided only on a paper basis or not at all, students have little choice to refer to learning tools. In contrast, our observations show that lecturers providing substantially more information in their lectures than presented on the used slides give students an incentive to use tools for making notes, annotations etc. Referring to our initial theoretical model (see Figure 2), social norm is not located at the same hierarchical level as the remaining exogenous factors. Our results rather suggest that exogenous social norm acts as antecedent condition for exogenous factors by restricting the range of useful learning tools to be applied.

In research question 3 we further investigated which learning tools are used for which tasks. Observations revealed three types of learners, i.e. students (1) preparing for an exam, (2) working on seminar papers, (3) or working on exercises. While students preparing for exams and writing on seminar papers refer mostly on writing and annotation tools, and wikiing tools, students solving exercises typically use course-specific software. Referring to the cognitive process dimensions (Bower et al. 2010), exam learners focus on lower order thinking skills, seminar writers on higher order thinking skills, and exercise solvers on medium order thinking skills. While the specific characteristics of the learning task shape the choice for the most appropriate tool, we do not find a direct link between the cognitive process dimensions and the learning tools used to support these learning tasks.
Similarly, our results show that even though some learning tools provide functionalities to be used for different learning tasks, these tools are only applied to a small amount of tasks residing mostly with lower order thinking skills. While students most likely create own content via presentation, shared document creation, and writing and annotation tools, only a small number of students create own wiki-articles or videos. Therefore, our results imply that even though students commonly refer to constructive and co-constructive learning tools, these tools are rather used in line with the transmissive pedagogy, e.g. to access and ‘consume’ content. Therefore, our

results show that videos and wikis are used in a transmissive rather than in a constructive or co-constructive manner (see Figure 1).
Therefore, the presented results for research question 1 stating students to follow mostly constructive approaches holds true only for a limited set of tools. The reason for that is that one main learning goal of the students is to prepare for an exam. During the preparation students lack the knowledge to create own content. However, after the exam the motivation to create or modify content is apparently obsolete. Therefore, the learning motivation and goals of student learners are different from the concept of lifelong learning of employees – the origin of PLEs. While student motivation seems to be rather short-term oriented, lifelong learning is based on a long-term perspective, i.e. acquiring knowledge and competences to remain competitive on the labour market (Attwell 2007).

The restriction for the learning tool selection imposed by education institutes is against the original considerations of PLEs claiming that learners develop and organise their learning environment on their own (Attwell 2010). Consequently, the concepts of PLEs and of university courses with a larger number (>30) of students do not match. Therefore, either the concepts of PLEs is not perfectly applicable to a university context and the concept has to be adapted, or the role of instructors has to change. Course instructors need to realize that they substantially influence the use of learning tools. First of all, they narrow down the range of possibly useful learning tools by their choice of how to organise and give lectures. Lecturers providing the slides in advance in an electronic manner give students more possibilities to work on the electronic slides. Furthermore, lecturers need to provide more support and guidance for the students' development and organisation of their PLE (Buchem et al. 2011). Regarding the organisational environment, universities can actively support students in their shift towards a higher usage of e-learning tools. Our results show that aspects of ease of use and familiarity act as a major barrier to the use of learning tools that would indeed fit the task characteristics and consequently would provide meaningful support to students. Therefore, universities should offer and actively promote free training courses, highlighting the possibilities and value-added of learning tools.

However, the observed misfit can also be rooted in the concept of PLEs which clearly calls for further attention in future research. Whilst we have focused on two German universities, the range of education institutes and used pedagogies is broad. Therefore, future research should investigate whether the current concept of PLEs better fits in the context of Universities of Applied Sciences or within company-internal training and teaching activities. Typically, the number of students following a course is substantially higher at universities compared to Universities of Applied Science and company training classes. In the context of university settings, future research should investigate which incentives are needed for students to use learning tools also for higher order thinking skills. Additionally, also university courses differ in their number of attending students and their educational objectives. Future research could use our results as a basis and go into more detail by distinguishing between different university course formats and their impact on the appropriate use of learning tools.

One of the aspects limiting the generalisability of our results is the focus on a narrow group of university students from two German universities. The majority of students participating in the questionnaires and the observations are enrolled in the fields of

computer science, natural science, or business and economics. Furthermore, these participants seem to be characterised by a high affinity towards electronic devices reflected in their intensive use of electronic devices on a daily basis. Other courses for example in the field of social studies either had a very small number of students or were not offered at the respective universities. Students enrolled in different fields of studies might be less familiar with computers, which could affect the participants' attitude towards learning tool selection and usage (Venkatesh and Bala 2008). Furthermore, observations inside lectures were limited to courses with a minimum number of about 30 students, so that we could maintain anonymous. During the observations we were only able to estimate age and field of study, and we were only able to get a rough idea about the use of specific tools and the underlying rationale due to the kept distance. As a consequence, we faced difficulties making detailed observations regarding the use of small devices such as tablets and smartphones. Last, we have only considered the perspective of students. However, prior research has shown that lecturers face more difficulties identifying the added value of e-learning tools (McGill and Hobbs 2008). Therefore, future research should consider both perspectives, i.e. the students' and the lecturers' perspectives. The use of both perspectives will be necessary to follow the long-term research objective of identifying all factors relevant for blended learning and understanding their interactions. This understanding, however, is an important prerequisite for providing blended learning in an optimal way for students and lecturers.

6.0 Conclusion

In the present study we have investigated the choice behaviour of students selecting tools to support their learning activities. Most of the university students use learning tools ranging from presentation and shared document creation tools over LMS, wikiing tools to video consumption and creation tools. Students' learning tool selection is based on exogenous and individual factors. Even though individual factors are perceived to be more important by students than exogenous factors for the learning tool selection, exogenous social norm plays a major role by limiting the range of possible tools to be used and consequently act as antecedent conditions. We find universities and lecturers to prescribe a specific range of possible tools to be used by referring to centralized LMSs and using standardized formats for their learning materials. Similarly, critical mass and network effects overrule individual preferences of users in tasks characterized by the need for coordination. Furthermore, the degree of thinking skills required for the specific learning task shapes the decision for specific tools to some extent. Only in case these factors are considered, individual factors such as the usefulness, ease of use etc., come into play. This restriction contradicts the theoretical concept of PLEs. Finally, whilst most students use tools providing the possibility to create own content, such tools are rather used to facilitate lower order thinking skills and to consume information.

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